A comparison of native tallgrass prairie and plains bluestem forage systems for cow-calf production in the southern great plains

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A comparison of native tallgrass prairie and plains bluestem forage systems for cow-calf production in the Southern Great Plains[1,2]

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ABSTRACT: The objective of this study was to compare an introduced warm-season perennial grass (plains bluestem, *Bothriochloa ischaemum*) to native tallgrass prairie for cow-calf production. Three systems were used, two based on tallgrass prairie with two different forms of protein supplementation and one based on plains bluestem as the primary forage. The systems were as follows: 1) native tallgrass prairie with pelleted oilseed meal as the winter protein supplement (native-control); 2) native tallgrass prairie with limited access to wheat pasture as the winter protein supplement (native-wheat); and 3) plains bluestem with limited access to wheat pasture as the protein supplement (bluestem-wheat). Oilseed meal protein supplements were fed twice weekly. Cows grazing wheat pasture were allowed 6 h of grazing twice weekly. Ninety-nine cows per year were used over the 3-yr study. Cows were sired by either Charolais, Gelbvieh, Angus, or Hereford bulls out of commercial Angus-Hereford dams. Calves were sired by Simmental bulls. Calving and weaning rate increased over time but did not differ among systems or breed types. System did not influence the size or body condition score of cows or the performance of calves, but changes in the weight and condition scores of cows were greater on either native system than on the bluestem-wheat system. Cows from Charolais and Gelbvieh bulls were taller ($P < 0.05$), and heavier ($P < 0.05$), and weaned heavier ($P < 0.05$) calves than cows from Angus or Hereford bulls. The weight of cows on the bluestem-wheat system tended to decrease over time, whereas cows grazing on the native systems tended to gain weight over time. The native-control system was the most profitable system based on cow production. If excess hay produced from the bluestem-wheat system was sold as a cash crop, then this system was the most profitable. In general, we conclude that limit-grazing wheat pasture is a viable alternative to oilseed meal as protein supplement for wintering dry cows. Although the bluestem system had 2.5 times the carrying capacity of the native prairie systems, increased productivity was offset by increased production costs. All systems were equal on a cow basis for providing nutrients for the cow-calf production system.

Key Words: *Bothriochloa ischaemum*, Cattle, Protein Supplements, Rangelands, Wheat

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Introduction

Historically, native tallgrass prairie has been the standard forage base for year-round cow-calf production systems in the Southern Great Plains. Dormant standing tallgrass forage, stockpiled for winter grazing, is normally low in quality, with CP as low as 4% and DM digestibility as low as 40% (Coleman and Wyatt, 1982). Introduced warm-season perennial grasses, such as plains bluestem (*Bothriochloa ischaemum*, var. ischaemum), have proven more responsive to an increase in summer rainfall and N fertility as well as providing better late-season productivity than native rangeland (Taliaferro et al., 1972). Animal gains per hectare ranged from four to eight times that of native rangeland during the growing season (Phillips and Coleman, 1995) and in year-long growth trials (Sims, 1985). This increase in animal productivity on introduced warm-season perennial grass was largely due to an increase in stocking rate, which effectively decreases the amount of residual forage available for grazing during winter because of increased utilization during the grazing season. Cow-calf producers have questioned whether to

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plow out rangeland and plant improved grasses such as bermudagrass (*Cynodon dactylon* [L.] Pers.) or plains bluestem. Whereas data are available for stocker steers during the growing season, comparisons are scarce for year-long systems for cow-calf production using native prairie and any of the Old World bluestems, of which the plains variety is one. The objectives of this study were to compare two forage systems based on native tallgrass prairie with one using plains bluestem for year-long cow-calf production and to evaluate winter wheat (*Triticum aestivum* L.) as a protein supplement.

Materials and Methods

The study was conducted at the Grazinglands Research Laboratory, west of El Reno, Oklahoma. The site was largely an upland loamy prairie consisting of the Bethany (fine, mixed, thermic, Pachic Palenstoll), Norge, and Pond Creek silt loam (fine-silty, mixed, thermic Udic Paleustolls) soils with about 15% in waterways, which were a Port silt loam series (fine-silty, mixed, thermic Cumulic Haplustoll). The native tallgrass prairie pastures were assessed for overall condition in October 1991 and January 1996 by the visual observations of rangeland specialists from the USDA-Natural Resources Conservation Service (NRCS, 1976).

Treatments consisted of three forage systems with two replicates of each system. The native-control system consisted of a single 65-ha native tallgrass prairie pasture per replicate grazed by 16 cows under a year-round continuous grazing management. Winter supplement consisted of 1.2 kg/d of a 41% CP pelleted soybean (1994) or cottonseed meal (1995–96) fed twice weekly from approximately Nov. 15 to May 1 each year. Each replicate of the native-wheat system consisted of a 65-ha native tallgrass prairie pasture divided into four paddocks and 4 ha of wheat pasture grazed by 18 cows. The cows grazed three of the four 16-ha paddocks during the summer under a 3-wk rotational system. The fourth paddock was grazed during the winter because of its proximity to the wheat pasture. Cows were allowed to graze the wheat pasture for 6 h/d twice each week beginning when sufficient wheat forage was available (approximately Nov. 15) until the wheat reached maturity (approximately May 1) each year. The bluestem-wheat system consisted of 22 ha of plains bluestem in two 11-ha paddocks, and 4 ha of wheat pasture grazed by 18 cows (Replicate 1) or 16.5 ha of bluestem (divided into two equal paddocks) and 3 ha of wheat pasture grazed by 13 cows (Replicate 2). Cows were restricted to one of the bluestem paddocks during the spring and summer (May–Oct.). Hay was harvested from the other paddock in late June. Regrowth was allowed to accumulate and was grazed during the winter (Nov.–May). Cattle were allowed access to wheat pastures twice weekly as in the native-wheat system. Hay cut from the plains bluestem pasture was fed in large round bales at 4.5 kg/d during the winter.

Native pastures contained 24 to 60% big bluestem (*Andropogon gerardii* Vitman.) and 1 to 15% little bluestem (*Schizachyrium scoparius* [Michaux] Nash). Indiangrass (*Sorgastrum nutans* [L.] Nash) was a major constituent of the native-control pastures and tall dropseed (*Sporobolus asper* [Michx.] Kunth) was a component (11 to 36%) of the native-wheat pastures. About 80% of the pasture area was classified as a loamy prairie range site, with 20% classified as a loamy bottomland range site. The stocking rate for the native-control pastures of about 3.8 animal unit-months (**AUM**)/ha was typical for central Oklahoma. Two extra cows were added to the native-wheat system because the wheat pasture provided additional forage. The stocking rate of about 11.8 AUM/ha for the bluestem-wheat pastures was based on previous work with summer stocker cattle (Coleman and Forbes, 1998). The plains bluestem pastures were fertilized with 84 kg of N/ha as urea in April each year. Wheat pastures were established each fall following a summer fallow period of approximately 90 d. Wheat was seeded at a rate of 110 kg/ha with a no-till drill. Before planting, 78 kg of N/ha was applied as urea. Cows had access to protein supplement, whether wheat pasture or oilseed meal, on Mondays and Thursdays of each week starting after the first freeze (or when wheat pasture was available), approximately Nov. 15, and ended when wheat pasture was exhausted, approximately May 1 each year.

The cows used in this study were produced over a 3-yr period (1989–1991) from Angus-Hereford dams bred either to Charolais, Gelbvieh, Angus, or Hereford sires. Ninety-nine cows were assigned within age and breed of sire to one of the three forage systems. Twenty-one additional cows were kept as replacements for any cows lost due to death or culling over the 3-yr period. All replacements came from these cows, and no replacement heifers were saved. Cows that died during calving were replaced at the beginning of the breeding season. Any cows open for two consecutive years were culled and replaced when pregnancy-checked at weaning. The cows were placed on their respective pastures in May 1993 and cow weights and body condition scores taken at weaning in 1993 were used as the initial data for calculating weight and condition score changes during the subsequent winter. Heifers were bred to Red Poll bulls for their first calf, and all cows were thereafter bred to Simmental bulls; only offspring from Simmental bulls were analyzed in this study as all cows had produced at least one calf before the beginning of the study. Different bulls were purchased each year and were rotated at 3-wk intervals among the forage systems within year. The 60-d breeding season began on approximately May 15 each year.

Body weights and body condition scores (1 to 9; Richards, et al., 1986) of cows were taken at the beginning of the breeding season (on approximately May 15) and at weaning (on approximately Oct. 15) each year. Calf weights were taken at birth, at the beginning of the subsequent breeding season, and at weaning. Hip

Table 1. Pasture range condition[a] at the beginning and end of the study

System	Grazing plan	Initial condition (10/91)	Final condition (1/96)
Native-control	Continuous, one pasture		
Replicate 1		Excellent	Excellent
Replicate 2		Excellent	Excellent
Native-wheat	Rotation, four pastures		
Replicate 1a[b]		Excellent, large waterway	Excellent
Replicate 1b		Low good; excellent spots; rest poor	High good
Replicate 1c		Low excellent; large patches of single species (big, little bluestem)	Excellent
Replicate 1d		High fair; three-awn, silverbeard, and other increasers prevalent	Low excellent
Replicate 2a		Fair with contrast of poor and excellent strips	Low good; tall dropseed, gramma grasses
Replicate 2b		Excellent	Low excellent
Replicate 2c		High poor; mostly three-awn	Low excellent
Replicate 2d		High fair	High good

[a]Range condition scores based on NRCS (1976).
[b]Replicates were 85-ha pastures divided into four (a, b, c, d) equal paddocks for rotation.

heights of both cows and calves were taken at weaning. All weights were single weights taken after an overnight fast; however, calves were left with their dams. Winter and summer changes in weight and body condition score were calculated for the cows. Calving percentage, calves weaned per cow, and cow replacement rate were determined. Two expressions of cow efficiency, calf weight-to-cow weight ratio, and kilograms of calf produced per kilogram of cow exposed were also calculated. Calf production per hectare and economic returns were calculated from the system means.

All variables describing cows and calves were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). System replicate was the experimental unit, and replicate and all interactions with replicate were considered as random variables. Fixed effects in the model included forage system, dam's breed-of-sire, age of dam, and their interactions in a factorial arrangement. Year was also considered fixed as a split plot in time. Because age of dam was partially confounded with year, the interaction was excluded. Age of dam was excluded from the model when analyzing the binomial data of calving, weaning, and cow replacement rate. Least square means were calculated and separated by Student's t-test when the F-test was significant ($P <$ 0.05).

Results and Discussion

The native-control pastures were in excellent rangeland condition at the beginning of the study and remained excellent (Table 1), although some patch grazing was evident at the end of the experiment. Rangeland condition for the paddocks in the native-wheat system was scored from poor to excellent condition in 1991, and increased in condition during the study. All paddocks were rated low-good or better in January 1996. This implies that the stocking rate and rotational management that we used had a positive influence on the rangeland condition.

Main Effects. Cow weights at weaning (Table 2) were about 75 kg heavier than at breeding, indicating excellent-quality forage during the growing season. Cows on either of the native range systems gained more ($P <$ 0.10) weight and attained higher body condition scores during the summer grazing season than cows on the bluestem-wheat system (Table 2). Forage system did not influence other measures of performance in the cows or calves. Four- and 5-yr-old cows gave birth to heavier ($P < 0.05$) calves than 3-yr-old cows (data not shown).

Sire breed of dam (breed type) significantly influenced cow weight at the beginning of the breeding season, and weight and height at weaning (Table 2). At breeding and weaning, Charolais- and Gelbvieh-sired cows were heavier ($P < 0.05$) than either Angus- or Hereford-sired cows. At weaning, Charolais- and Gelbvieh-sired cows were taller at the hip ($P < 0.05$) than both Angus- and Hereford-sired cows, and Hereford-sired cows were taller ($P < 0.05$) than Angus-sired cows.

Size and scale of calves were influenced ($P < 0.05$) by breed type (Table 3). Like their mothers, calves from Charolais- and Gelbvieh-sired cows were heavier at birth ($P < 0.10$) and taller at weaning ($P < 0.05$) than those from Angus- or Hereford-sired cows. Calves from Gelbvieh-sired cows were heavier ($P < 0.05$) at breeding and at weaning than any other breed type, and Charolais-sired cows weaned heavier calves than Angus- or Hereford-sired cows.

Weight per day of age, which combines birth weight and rate of growth, followed similar trends, although calves from Angus-sired cows were not different from those sired by Charolais-sired cows ($P > 0.05$). Calving rate, weaning rate, and calf weight weaned per kilogram of exposed cow were not influenced by either forage system or breed type. However, these variables increased with years into the study, probably an influence of the age of cows (data not shown).

Table 2. Effect of forage system or breed type on weight, body condition score, and hip height of cows at breeding and at weaning[a]

Item	Forage system[b]				Breed type[c]				
	Native-control	Native-wheat	Bluestem-wheat	SE[d]	Angus	Hereford	Charolais	Gelbvieh	SE[d]
Number of cows/yr	32	36	31		14	29	30	26	
Calves born/cow	0.91	0.90	0.90	0.04	0.85	0.93	0.94	0.89	0.04
At breeding									
Cow weight, kg	445	465	472	10.0	437[g]	449[g]	478[h]	479[h]	8.8
Weight change, kg[e]	–53	–48	–27	4.7	–36	–43	–48	–46	5.4
Condition (1 to 9)	4.6	4.7	4.9	0.09	4.8	4.8	4.6	4.8	0.10
Condition change[e]	–0.88	–0.77	–0.46	0.09	–0.62	–0.77	–0.69	–0.74	0.10
At weaning									
Weight, kg	534	549	534	12.4	508[g]	529[g]	562[h]	557[h]	9.3
Weight change, kg[f]	89[k]	87[k]	62[j]	3.9	75	80	84	78	4.5
Condition (1 to 9)	5.4	5.4	5.3	0.14	5.4	5.5	5.2	5.3	0.13
Condition change[f]	0.75[k]	0.73[k]	0.35[j]	0.08	0.61	0.72	0.57	0.55	0.09
Hip height, cm	129	130	131	0.8	125[g]	130[h]	133[i]	132[i]	0.7
Calves/cow	0.87	0.84	0.84	0.04	0.82	0.87	0.89	0.81	0.04
Replacement rate, %	3.5	5.2	5.7	2.53	7.5	2.7	4.6	4.4	2.81

[a]Least square means.
[b]Native-control = native pasture with oilseed cake winter protein supplement; native-wheat = native pasture with wheat pasture as winter protein supplement; bluestem-wheat = plains bluestem with wheat pasture protein supplement and hay.
[c]Breed type refers to the breed of sire for the cows.
[d]Standard error of the mean.
[e]Change in weight or condition score during winter, from previous weaning to current breeding season.
[f]Change in weight or condition score during summer, from breeding to weaning.
[g,h,i]Within a row, means without a common superscript letter differ among breed types ($P < 0.05$).
[j,k]Within a row, means without a common superscript letter differ among forage systems ($P < 0.10$).

Year × Forage-System Interaction. An interaction ($P < 0.05$) was observed for forage system × year for all measures of weight and body condition of the cows (Table 4). In 1994, BW and condition scores at breeding and weaning were higher ($P < 0.05$) for cows on the bluestem-wheat system than for cows grazing the native pastures, but weight and condition were not different among systems in 1995 or 1996. In general, cows on the two native systems increased in weight over time, whereas those on the bluestem-wheat decreased over time. Also, weight change from the previous weaning to the beginning of the breeding season (winter gain) was positive for cows grazing the bluestem-wheat system in 1994, whereas the native systems produced

Table 3. Effect of forage system or breed type on calf birth weight and growth traits through weaning and estimates of cow efficiency[a]

Item	Forage system[b]				Breed type[c]				
	Native-control	Native-wheat	Bluestem-wheat	SE[d]	Angus	Hereford	Charolais	Gelbvieh	SE[d]
Birth weight, kg	40.0	41.5	40.2	0.80	39.0[i]	39.5[i]	41.9[j]	41.8[j]	0.91
Weight at breeding, kg	94.4	95.5	97.9	2.75	94.2[i]	94.7[i]	92.2[i]	102.7[j]	3.06
Weight at 205 d, kg[e]	251	233	238	4.6	231[i]	232[i]	243[j]	258[k]	4.4
Weight at weaning, kg	266	252	255	6.9	246[i]	250[i]	257[i]	278[j]	5.9
Height at weaning, cm	115	115	116	1.1	113[i]	114[i]	117[j]	117[j]	0.9
Wt/d of age, kg[f]	1.21	1.12	1.15	0.02	1.12[ij]	1.11[i]	1.17[j]	1.24[k]	0.02
Wt/dam wt, kg/kg[g]	0.51	0.46	0.51	0.01	0.50[jk]	0.48[ij]	0.47[i]	0.52[k]	0.01
Cow efficiency, kg/kg[h]	0.42	0.37	0.40	0.03	0.40	0.40	0.42	0.35	0.03

[a]Least square means.
[b]Native-control = native pasture with oilseed cake winter protein supplement; native-wheat = native pasture with wheat pasture winter protein supplement; bluestem-wheat = plains bluestem with wheat pasture protein supplement and hay.
[c]Breed type refers to the breed of sire for the cows.
[d]Standard error of the mean.
[e]Calculated from formula: $Y = (205 \cdot ADG) +$ birth weight.
[f]Weaning weight/age in days at weaning.
[g]Weaning weight of calf divided by weight of cow at weaning.
[h]Calf weight weaned per kilogram of cow exposed.
[i,j,k]Within a row, means without a common superscript letter differ among breed types ($P < 0.05$).

Table 4. Effect of forage system on weight, body condition score, and hip height of cows at breeding and at weaning during each year[a]

	Native-control[b]			Native-wheat			Bluestem-wheat			
Item	1994	1995	1996	1994	1995	1996	1994	1995	1996	SE[c]
Number of cows	32	32	32	36	36	36	31	31	31	—
Calves born/cow	0.79	0.93	1.00	0.75	0.96	1.00	0.83	0.92	0.94	0.07
At breeding										
Cow weight, kg	427^{f}	454^{fg}	455^{fg}	457^{fg}	484^{gh}	456^{fg}	508^{h}	459^{fg}	451^{fg}	14.5
Weight change, kg[d]	-50^{gh}	-35^{ghi}	-73^{fg}	-9^{i}	-29^{hi}	-89^{f}	24^{j}	-41^{gh}	-56^{fgh}	10.5
Condition (1–9)	4.6^{fg}	4.6^{fg}	4.7^{fg}	5.0^{g}	4.8^{g}	4.4^{fg}	5.9^{h}	4.6^{fg}	4.2^{f}	0.18
Change in condition[d]	-0.76^{fgh}	-1.00^{fg}	-0.89^{fg}	-0.47^{h}	-0.70^{fgh}	-1.14^{fg}	0.38^{i}	-1.16^{f}	-0.61^{gh}	0.19
At weaning										
Weight, kg	513^{f}	539^{fg}	551^{fg}	504^{f}	564^{g}	579^{g}	555^{g}	537^{fg}	505^{f}	16.1
Weight change, kg[e]	87^{gh}	85^{gh}	94^{gh}	49^{f}	70^{fg}	121^{h}	48^{f}	76^{fg}	58^{fg}	12.1
Condition (1–9)	5.5^{g}	5.4^{g}	5.4^{g}	5.4^{g}	5.5^{g}	5.4^{g}	6.2^{h}	5.1^{g}	4.4^{f}	0.24
Change in condition[e]	0.88^{hi}	0.76^{hi}	0.61^{fghi}	0.36^{fg}	0.71^{ghi}	1.11^{i}	0.33^{f}	0.49^{fgh}	0.24^{f}	0.15
Hip height, cm	128	130	131	128	130	132	130	132	132	1.16
Calves/cow	0.79	0.91	0.91	0.72	0.83	0.98	0.71	0.86	0.94	0.06
Replacement rate, %	2.5	5.0	3.1	4.2	2.9	8.4	8.3	2.6	6.1	4.49

[a]Least square means.
[b]Native-control = native pasture with oilseed cake as winter protein supplement; native-wheat = native pasture with wheat pasture as winter protein supplement; bluestem-wheat = plains bluestem with wheat pasture as winter protein supplement and hay.
[c]Standard error of the mean.
[d]Change in weight or condition score during winter, from previous weaning to current breeding season.
[e]Change in weight or condition score during summer, from breeding to weaning.
[f,g,h,i,j]Rows of means with superscripts indicate year × systems interaction. Within a row, means without a common superscript letter differ ($P < 0.05$).

weight losses. Summer gains were approximately the inverse of winter weight changes.

The year × system interaction ($P < 0.05$), for condition score at weaning and for change in condition score over the summer, was confined to years within the bluestem-wheat system (Table 4). In 1994, the body condition score for cows grazing bluestem-wheat averaged 6.2 at weaning and in 1996, averaged only 4.4. Because of a spring drought in 1996, the cows on the bluestem-wheat system were not able to recover the condition lost during the previous winter.

The year × forage system interaction for height at the hips of cows was not significant ($P > 0.05$), but height generally increased over years in each system, indicating the maturing of the cows. The overall mean percentage of calves born and weaned was 90 and 83%, respectively, and was not different ($P > 0.05$) due to the system, year, or their interaction. Also, the rate of attrition and necessary replacement averaged 4.9% and was not different ($P > 0.05$) among years or systems.

Calf weight at the beginning of the breeding season, at 205 d of age, and at weaning, and the weight per day of age were influenced by the interaction of forage system and years (Table 5). Calf weight at breeding was greater on systems with wheat pasture than for the native-control system during 1995 ($P < 0.05$), but not in other years. Calculated 205-d weights and measured weaning weights of calves were lower ($P < 0.05$) for the native-wheat system than the other forage systems in 1994 (Table 5). In 1996, calves from the native-control system were heavier at 205 d and at weaning than those from the bluestem-wheat system.

An interaction ($P < 0.05$) was observed for weight per day of age because the rate of gain was lowest for calves reared on native-wheat in 1994 compared with the other two systems, and higher ($P < 0.05$) for calves on the native-control system than on bluestem-wheat in 1996. There was a general trend for rate of gain and 205-d weight for calves on the bluestem-wheat system to decrease over years, whereas gain and 205-d weight for calves on the two native systems either increased or were stable over years. Calf height was not affected by system or the interaction of system with year.

The ratio of calf weight to dam weight averaged 0.49 across all years and systems. Cow efficiency—a function of calf weaning weight, weaning percentage, and weight of the cow—averaged 0.41 kg/kg. Neither variable differed among forage systems or years ($P > 0.05$).

Forage System by Dam's Breed of Sire Interaction. There was a breed type × forage system interaction ($P < 0.05$) for two cow traits (weight at breeding and weaning) and three calf traits (weight and height at weaning, and weight per day of age; data not shown). Measures of calf size and scale followed trends similar to those for their dams and were generally accounted for by breed type (Tables 2 and 3). Due to the small numbers within each cell, and because the interaction generally occurred for measures of size and scale rather than for change in weight or body condition, we attribute the interaction to initial assignment rather than to any influence of the forage system on the performance of different breed types.

Economics. Cost of production per cow was $85 more for the bluestem-wheat than for the native-control production system (Table 6), but stocking rates were 2.5 higher. Those extra costs were primarily fertilizer and hay costs. Winter feed costs charged for wheat pasture on the native- and bluestem-wheat systems were $10 less (per cow) than actual costs for cows fed oilseed cake on the native-control pastures, but overall costs were higher for native-wheat.

Gross returns per cow were greater for the native-control system because both weaning percentage and weaning weight were somewhat higher ($P > 0.05$) than for the other systems. Gross return per hectare was about threefold higher for the bluestem system due to the increased stocking rate. Net returns were positive only for the native-control system. Extra hay was harvested from the bluestem-wheat system, and, when added as an additional return, this system actually produced more net income per hectare ($74) than either the native-control ($10) or native-wheat (–$10) systems.

Discussion. Averaged across all systems, winter weight losses of cows were modest (35 ± 5 kg) in 1995 and quite severe (66 ± 5 kg) in 1996 but were not different ($P > 0.05$) among forage systems. Similar changes were noted in body condition score and essentially reflected the changes in BW. Body condition scores averaged approximately 5.4 at weaning and indicated excellent condition going into winter.

There was no consistent biological advantage for any of the systems when averaged over breed types and years. This suggests that our stocking rates were either at or below optimum. The stocking rates for the bluestem-wheat system were extrapolated from our experiences with grazing stocker cattle during the summer growing season (Phillips and Coleman, 1995; Coleman and Forbes, 1998). Stocking rates used for native pastures were well established by many years of grazing by cows and by following NRCS (1976) *Technical Guide* recommendations. Although the bluestem system did not challenge the cows as severely as we had thought, there was a trend for cow weights and condition, both at breeding and weaning, to decrease over the 3-yr study. Precipitation was below normal from October 1995 throughout all of 1996 (except for August), and that may have restricted the available forage on both the plains bluestem and wheat pastures. The trend also was influenced by heavier cows on the bluestem-wheat system in 1994 compared with the native systems (Table 4).

We hypothesized that the bluestem-wheat system would nutritionally challenge the cows primarily because of the 2.5-fold increase in stocking rate. Even though fertilized plains bluestem produces about three times the forage of native rangeland (Taliaferro et al., 1972), we anticipated that the increased grazing pressure would limit the quantity of standing hay going into fall. An unaccounted source of nutrients, particular in dormant native prairie, is the winter annual, such as *Bromus*. The annuals are a natural part of the tall-grass prairies but are in quite small quantity per hectare, especially during the winter. The greater stocking rate would decrease the area per cow and likely the density of winter annuals on the plains bluestem pastures compared with the tall-grass prairie pastures. Lawrence et al. (1995) compared native rangeland to plains bluestem with variable quantities of protein supplementation (25 to 175% of that used on rangeland) for wintering cows. Stocking rates were similar to those used in the current study. They found that only 75% as much protein was required by cows grazing bluestem pastures to produce changes in prepartum weight and condition score similar to those of cows grazing on the native system. After calving, however, weight loss occurred less on the rangeland system than with any protein level on the bluestem systems. Cows on the native system initiated positive weight gain earlier

Table 5. Effect of forage system on calf birth weight and growth through weaning and estimated cow efficiency during each year[a]

	Native-control[b]			Native-wheat			Bluestem-wheat			
Parameter	1994	1995	1996	1994	1995	1996	1994	1995	1996	SE[c]
Birth weight, kg	41	38	41	41	43	41	43	39	38	1.6
Weight at breeding, kg	88^{hi}	99^{i}	96^{i}	83^{h}	114^{j}	93^{hi}	88^{hi}	114^{j}	91^{hi}	4.6
Weight at 205 d, kg[d]	251^{jk}	244^{ijk}	258^{k}	220^{h}	240^{hijk}	239^{hijk}	252^{jk}	236^{hij}	228^{hi}	7.5
Weight at weaning, kg	253^{ij}	278^{kl}	269^{jkl}	219^{h}	281^{l}	257^{ijk}	249^{ij}	279^{kl}	237^{hi}	10.0
Height at weaning, cm	113	116	117	110	117	117	113	118	116	1.5
Wt/d of age, kg[e]	1.23^{j}	1.17^{ij}	1.25^{j}	1.08^{h}	1.14^{hi}	1.15^{hij}	1.23^{j}	1.11^{hi}	1.10^{hi}	0.03
Wt/dam wt, kg/kg[f]	0.50	0.52	0.50	0.42	0.66	0.58	0.46	0.55	0.50	0.08
Cow efficiency, kg/kg[g]	0.43	0.43	0.40	0.37	0.39	0.34	0.35	0.43	0.42	0.06

[a]Least square means.

[b]Native-control = native pasture with oilseed cake as winter protein supplement; native-wheat = native pasture with wheat pasture as winter protein supplement; bluestem-wheat = plains bluestem with wheat pasture as winter protein supplement and hay.

[c]Standard error of the mean.

[d]Calculated from formula: $Y = (205 \cdot ADG) + \text{birth wt.}$

[e]Weight per day of age = weaning weight/age in days at weaning.

[f]Weaning weight of calf divided by weight of cow at weaning.

[g]Calf weight weaned per kilogram of cow weight.

[h,i,j,k,l]Rows of means with superscripts indicate year × system interaction. Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 6. Partial economic analysis of forage production systems

Item	Native-control	Native-wheat	Bluestem-wheat
	Forage system		
Native range, ha/cow	4.06	3.61	—
Improved pasture, ha/cow	—	—	1.24
Wheat pasture, ha/cow	—	0.22	0.22
Expenses			
	Permanent pasture, $/cow		
Land[a]	320	284	242
Fencing	—	76	21
Establishment[b]	—	—	27
Fertilizer[c]	—	—	69
	Winter supplement, $/cow		
Feed[d]	54	—	—
Hay[e]	—	—	47
Wheat pasture[f]	—	44	44
Labor and Eqt.	21	30	30
Total costs, $/cow	395	434	480
Total costs, $/ha	97	113	324
Returns			
Number of calves[g]	0.87	0.84	0.84
Weaning wt, kg	267	252	254
Value/cow, $[h]	434	396	399
Value/ha, $	107	103	273
Net return, $/cow	39	–38	–81
Net return, $/ha	10	–10	–51
Hay, kg/ha[i]	—	—	1,900
Value, $/ha[i]	—	—	125

[a]Interest on capital at 8%. Rangeland valued at $988/ha; Bluestem and wheat pasture valued at $2,470/ha.

[b]Establishment cost for bluestem pastures amortized over 10 yr plus interest.

[c]Bluestem pastures were fertilized with 85 kg of actual N/ha each year.

[d]Cows on native-control pastures fed 1.2 kg/d range cubes consisting of 95% oilseed meal and 5% molasses @ $0.24/kg. Fed from approximately Nov. 15 to May 1 each year.

[e]Cows on bluestem-wheat pastures fed hay at 4.25 kg/d @ $0.066/kg from Nov. 15 to May 1.

[f]Wheat pasture land and establishment costs of $200/ha.

[g]Average number of calves weaned per cow.

[h]Calves/cow × numbers of calves × selling price; selling price per kilogram of calf sold is the average over the 3 yr at the Oklahoma City market ($1.87/kg).

[i]Hay produced in excess of that fed. Priced at $0.066/kg.

than those on the bluestem pastures (F. T. McCollum, III, personal communication). Such results confirmed our concerns about the ability of intensively grazed improved pastures to supply nutrient needs throughout the winter. Annual bromegrasses, other winter grasses, and forbs are the most prevalent in the early spring on native rangelands of the Southern Great Plains, and they no doubt supplied some of the protein and energy needs for cows on that system. Like cows in our study, summer gains in BW and condition score were inversely related to those during the winter, indicating the ability of the cows to compensate.

Because we expected the bluestem pastures to provide insufficient nutrients for the cows, particularly larger and heavier milking types, such as the Charolais and Gelbvieh, we added the bluestem hay to the bluestem-wheat system. Adams et al. (1994) also provided hay to cows grazing either native rangeland or subirrigated meadow during the winter in Nebraska, but the hay was provided only after calving. In retrospect, a more challenging system for the current study could have been developed with plains bluestem if the hay had been fed only after calving.

Sims (1993) and Sims and Bailey (1995) compared two forage systems based on native rangeland: a control very similar to the one used in the current study and one with the complementary forages. For the second system, they replaced 30% of the 7.4 ha/cow rangeland with 0.5 ha of double-cropped farmed forage, wheat for winter, and forage sorghum for summer grazing. They reported heavier cow weights at weaning (Sims, 1993) but lighter calf weights at 200 d of age for cattle on the complementary forage system (Sims and Bailey, 1995). Their forage systems also included different calving seasons to optimize the use of the forage supply. Actual weaning weights were greater for the complementary forage system, due largely to older weaning age. Their data, as well as ours, indicate one of the problems with system-level research: a confounding of components that leads to difficulty in determining the cause of observed differences among systems.

High input costs for the bluestem-wheat system reflect the costs of increasing production intensity and include the establishment of the introduced warm-season perennial grass pastures, increased fencing requirements, and haying. A large part ($55) of the difference in total costs for the native-wheat vs the native-control system was for cross-fencing of the rangeland pastures. We included cross-fencing and rotational-grazing management as part of the system and concluded that the practice resulted in a benefit to the rangeland in terms of improved condition (Table 1). However, the winter wheat portion could be implemented without the fencing at about the same cost as supplementation. Increased labor and equipment costs for wheat pasture ($30/cow) over supplementation ($21/cow) were due primarily to the time required to move cattle relative to that required to dispense the cake two times per week. Labor to retrieve cattle from wheat pasture became a problem after calves were born because calves often became separated from their mothers and were more difficult to drive.

The more intensive bluestem-wheat system cost $85 and $46 more per cow than the native-control or native-wheat system, respectively. This factor increases the risk associated with intensification but has the benefit of potentially producing a cash crop from the hay that is not used by the cows in the system. If the cost:return ratio is favorable, the 2.5-fold increase in stocking rate would result in a higher return per unit of land, but losses would also be magnified. Whitson and Kay (1978) evaluated an array of systems using a linear programming economic model and stated that intensified production systems using improved forage species become economically feasible only with relatively higher calf prices.

The breed types used in this study were chosen to determine whether the forage systems could meet the demands of high producing cows such as the Charolais and Gelbvieh F_1 hybrids. They were taller and heavier ($P < 0.05$) than the Angus- and Hereford-sired cows (Table 2). Furthermore, their calves were generally taller and heavier (Table 3), and calves from Gelbvieh-sired cows were heavier at 205 d and at weaning than those from Charolais-sired cows. Though not measured in the current study, Jenkins and Ferrell (1992) reported that Gelbvieh had higher milk production than the other breeds they evaluated. They further reported that increased energy allowance did not influence the milk production of Angus and Hereford cows, but it linearly increased milk production in Charolais and Gelbvieh cows, suggesting greater nutritional requirements for maximum production.

Because all breed types grazed in the same pastures within a forage system, we could not separate the requirements for maintaining those cows compared with the smaller Angus- or Hereford-sired cows. Russel and Wright (1983) reported that maintenance requirements of cows were affected primarily by live weight and body condition score. Kronberg et al. (1986) observed that Simmental × Hereford cows consumed more forage as a percentage of BW than Herefords while lactating, but no differences were observed for nonlactationg cows. Ferrell and Jenkins (1985) reported that Charolais and Gelbvieh cows required more energy for maintenance than most of the breeds they evaluated. Jenkins et al. (2000) reported that weaning weight of different breeds of calves was significantly influenced by daily metabolizable energy intake of the cow, primarily through the influence of cow nutrition on milk production. In that study, calves had limited access to supplemental feed, whereas calves grazing pasture have the opportunity to select highly nutritious plant parts to supplement milk consumed (Grings et al., 1995). Jenkins and Ferrell (1994) reported an interaction between breed type and feed availability for anestrous periods and conception rate. Due to similar reproductive performance observed across systems in the current study, we must conclude that nutrition was not limiting for any of the breed types.

Although there was a statistical significance for the breed type × forage system interaction for cow weight and calf performance, there did not appear to be a credible reason for the differences observed. The interaction could have been caused by initial allotment because rather small numbers (13 to 18 cows) were in each cell. However, genetic × environmental interactions have been recognized as important since the report by Butts et al. (1971), in which Hereford cattle from Montana and Florida were exchanged. Sims and Bailey (1995) also reported genetic × environment interactions on systems similar to ours. However, they used fall vs spring calving, as well as different forage systems as the environmental differences, and Brahman-crossed cows as the genetic component. These more extreme differences in both environmental constraints and breed types may have been the major contributors to the interaction because they have been implicated before (Bolton et al., 1987).

When the two native rangeland systems are compared, the lack of difference in performance provides evidence that the wheat pasture grazed twice weekly and the oilseed meal fed twice weekly were both equally effective as protein supplements for cows. Wheat pasture was also effective as protein supplement in the studies by Sims (1993) and Sims and Bailey (1995), but cows had continuous access to the wheat, whereas we limited access to 2 d/wk in the current study. The practice of feeding protein supplement less frequently than daily has been substantiated by N balance (Coleman and Wyatt, 1982) and grazing trials (McIlvain and Shoop, 1962).

Implications

The results of this study indicate that both native tallgrass prairie and introduced plains bluestem pastures can adequately support cow-calf production systems. However, hay was an input for cows grazing dormant plains bluestem in the winter, and the assumption was that performance would be compromised without the hay. Even at 2.5 times the stocking rate of rangeland, the plains bluestem system produced enough hay to feed the respective cows during the winter with some left over that could be sold as a cash crop. Wheat pasture grazed twice weekly can adequately provide the protein needs to supplement dormant warm-season perennial grass forage and may reduce costs over oilseed supplements. Because of higher stocking rates, plains bluestem produced about 2.5 times as much beef per hectare as the native systems, but with greater input cost and, therefore, greater risks.

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